

REMARKS

Upon entry of this amendment, claims 1-9, 23, 24, 26, 27, and 29-40, are pending in this application. Of these, claims 1, 9, 23, 24, 26, 27, 29, 30, and 31 are independent. Claims 1-9, 23, 24, 26, 27, 29, 30, and 31 are amended. Claims 11-20, 21, 22, 25, and 28 are canceled. New claims 32-40 are added. Applicant believes that these changes introduce no new matter. Entry and consideration of this Amendment are respectfully requested. A copy of the above amendments showing deletions and insertions is attached to this Amendment (entitled "Attachment 1").

Specification and drawing amendments

The specification has been amended to change the term "secondary difference" to the term "second order difference." Applicant believes that these changes enter no new matter. Figures 7, 9, 10, 14, 16, 19, 20, 21, and 22 are also sought to be amended to change this term. Proposed changes to these drawings are filed herewith in a Request to Approve Proposed Drawing Changes.

Summary of outstanding claim rejections

Claims 1-9 and 11 are rejected under 35 U.S.C. §102(b) as being allegedly anticipated by U.S. Patent No. 5,091,970 to Takeo ("Takeo '970"). Claim 11 has been canceled, thereby rendering its rejection moot. However, Applicant respectfully traverses the rejection of claims 1-9.

Claims 12-14 are rejected under 35 U.S.C. §103(a) as being unpatentable over the '970 patent in view of U.S. Patent No. 4,992,663 to Takeo ("Takeo '663"). Claims 14, 23, 24, 26, 27, 29, 30, and 31 appear to be rejected on the same grounds. Applicant respectfully traverses these rejections.

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Claims 1, 23, and 26

Claim 1 is directed to an image processing method that determines a plurality of areas and calculates second order difference values. Claim 1 recites that the second order difference values are calculated from values, each representing a different one of the plurality of areas.

Takeo '970 discloses the presence or absence of a limited irradiation field. This is judged by comparing a representative value of an image signal corresponding a peripheral portion with a representative value of the image signal corresponding to the overall area or approximately a center portion.

Takeo '970 neither teaches nor suggests calculating second order difference values, as recited in claim 1. ✓

Further technical differences exist between claim 1 and Takeo '970. The method of claim 1 includes obtaining an end point of an irradiation area from the second order difference values. Takeo '970 neither teaches nor suggests this feature. Takeo '970 merely judges the presence or absence of a limited irradiation field. It does not obtain an end point of an irradiation area as recited in claim 1. ✓

U.S. Patent No. 4,992,663 to Takeo ("Takeo '663") fails to overcome the deficiencies of Takeo '970. Takeo '663 discloses in column 13 that, with respect to a discrete sampled image, a contour of an irradiation field is detected by performing calculation of a first or higher order difference between the values of neighboring image signal components. However, such difference calculations are not second order differences, as recited in claim 1. ✗

The second order difference in claim 1 is calculated from "values each of which represents a different one of the plurality of areas." As recited in claim 1, each of the plurality of areas includes a plurality of pixels that are arranged in a direction on the image. Such a structure of the present invention is not at all disclosed or suggested in Takeo '663. ✓

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Instead, the (second order) differences in Takeo '663 are calculated from values of neighboring image signal components. This is because Takeo '663 (e.g., the differentiation processing section 221) merely focuses on differentiation.

Accordingly, Applicant asserts that claim 1, and its dependent claims, are patentable over Takeo '970 and Takeo '663, taken alone or in combination.

In addition, apparatus claim 23 and storage medium claim 26 recite features similar to those recited in claim 1. Therefore, Applicant asserts that these claims are also patentable over Takeo '970 and Takeo '663, taken alone or in combination.

Claim 9

Independent claim 9 is directed to an image processing method that judges whether an irradiation area is limited in an object area of an image. This step is based on the detection of an irradiation area end point from pixel values in the object area.



However, as explained above, Takeo '970 merely judges the presence or absence of the limited irradiation field, and Takeo '663 merely detects the contour of the irradiation field. Thus, neither Takeo '970 nor Takeo '663 (taken alone or in combination) teach or suggest the features of claim 9. Accordingly, claim 9 and its dependent claims (new claims 32-40) are patentable over these references.


Independent claims 24 and 27 recite features similar to those recited in claim 9. Accordingly, Applicant asserts that these claims are also patentable over Takeo '970 and Takeo '663.

Claim 29

Independent claim 29 is directed to an apparatus for a radiographic image. The apparatus of claim 29 includes a unit adapted to calculate characteristics of radiographic image pixel values at every successive plural pixels arranged at intervals of at least two pixel pitches in the direction on the radiographic image. The apparatus of claim 29 further includes a unit adapted to obtain an irradiation area end point based on the calculated characteristics.

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As set forth above, pixel value characteristics (including differences) differences in Takeo '663 are calculated from neighboring image signal components. In contrast, the pixel value characteristics of claim 29 are calculated from pixel values at every successive plural pixels of the plurality of pixels arranged at intervals of at least two pixel pitches in the direction on the radiographic image. This feature is neither taught or suggested by Takeo '663. Takeo '970 also fails to teach or suggest this feature. 


In addition, further differences exist between claim 29 and the references applied by the Examiner. For instance, Takeo '970 judges the presence or absence of a limited irradiation field. However, it does not obtain an irradiation area end point, as recited in claim 29. 

Accordingly, Applicant asserts that claim 29 is patentable over Takeo '970 and Takeo '663. Independent claims 30 and 31 recite features similar to those recited in claim 29. Accordingly, Applicant asserts that these claims are also patentable over Takeo '970 and Takeo '663.

CONCLUSION

Applicant respectfully submits that all of the stated grounds of rejection have been properly traversed accommodated or rendered moot. Thus, Applicant believes that the present application is in condition for allowance, and as such, Applicant respectfully requests reconsideration and withdrawal of the outstanding rejections, and allowance of this application.

AUTHORIZATION

The Commissioner is hereby authorized to charge any additional fees which may be required for consideration of this Amendment to Deposit Account No. 13-4500, Order No. 1232-4532. A DUPLICATE OF THIS DOCUMENT IS ATTACHED.

In the event that an extension of time is required, or which may be required in addition to that requested in a petition for an extension of time, the Commissioner is requested to grant a petition for that extension of time which is required to make this

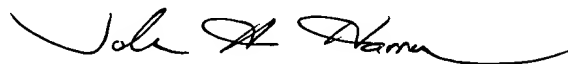
response timely and is hereby authorized to charge any fee for such an extension of time or credit any overpayment for an extension of time to Deposit Account No. 13-4500, Order No. 1232-4532. A DUPLICATE OF THIS DOCUMENT IS ATTACHED.

Respectfully submitted,
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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant(s) : Hiroyuki SHINBATA
Serial No. : 09/287,406 Group Art Unit: 2621
Filed : April 6, 1999 Examiner: B. Choobin
For: **IMAGE PROCESSING METHOD APPARATUS AND
STORAGE MEDIUM FOR RECOGNITION OF
IRRADIATION AREA**

ATTACHMENT 1

In this attachment, all additions are shown underlined (e.g., the), and deletions are shown in brackets (e.g., [the]).

IN THE SPECIFICATION

Please rewrite the paragraph from page 1, line 6 through page 1, line 9, as follows:

The present invention relates to an image processing method, an image processing apparatus, and a storage medium using second order [secondary] differences for recognition of an irradiation field.

Please rewrite the paragraph from page 4, line 21 through page 4, line 23, as follows:

a step of calculating a second order [secondary] difference value of density values representing the respective areas in the plurality of areas; and

Please rewrite the paragraph from page 6, line 8 through page 6, line 10, as follows:

a second order [secondary] difference value acquisition step of acquiring second order [secondary] differences values from one-dimensional image data of the object area;

Please rewrite the paragraph from page 6, line 11 through page 6, line 14, as follows:

an irradiation end extraction step of extracting a coordinate of an end point of the irradiation area from the second order [secondary] difference values acquired in the second order [secondary] difference value acquisition step;

Please rewrite the paragraph from page 9, line 20 through page 10, line 14, as follows:

Fig. 2 is a block diagram to show the inside structure of the irradiation area extraction unit 102, in which reference numeral 200 designates a calculation area input unit for accepting input of a direction, a start point, and an end point for determination of calculation areas and 201 a calculation area determination unit for determining, based on the input information at the calculation area input unit 200, areas of calculation carried out by a calculation unit 202 from the input image supplied from the image input unit 101. Numeral 202 denotes a calculation unit for calculating primary difference values and a second order [secondary] difference value, described hereinafter, from the calculation areas determined at the calculation area determination unit 201, 204 a judgment unit for judging irradiation area ends, 203 a memory unit for storing the values calculated at the calculation unit 202 and the irradiation area ends judged at the judgment unit 204, and 205 an irradiation area determination unit for determining the irradiation area from the irradiation area ends stored in the memory unit 203 and judged at the judgment unit 204.

Please rewrite the paragraph from page 10, line 15 through page 10, line 26, as follows:

Fig. 3 is a flow chart to show the flow of the processing at the irradiation area extraction unit 102. Fig. 4 is a diagram to show the calculation areas determined at the

calculation area determination unit 201. Fig. 5A is a diagram to show a radiographic image and Fig. 5B is a diagram to show density values on line X_0 to X_3 of Fig. 5A. The abscissa indicates positions on the line X_0 to X_3 and the ordinate density values on the line. Fig. 6A is an enlarged view of part of Fig. 5B. Fig. 6B is a plot of second order [secondary] difference values calculated at the calculation unit 202 against points on the above line between X_0 and X_3 .

Please rewrite the paragraph from page 11, line 12 through page 12, line 12, as follows:

The processing at the irradiation area extraction unit 102 of Fig. 2 will be described next according to the flow of Fig. 3. The irradiation area extraction unit 102 receives the input of the calculation direction, the calculation start point, and the calculation end point necessary for the determination of the calculation areas at the calculation area input unit 200 (step S301). It is, however, noted that the input herein is required only for an initial input screen and it does not have to be set for the next input screen and after. Next, the calculation area determination unit 201 determines the calculation areas, based on the information from the calculation area input unit 200. The calculation areas herein are three areas A, B, and C of a rectangular shape arranged in parallel on the image, as illustrated in Fig. 4, and are used as calculation areas for calculation of the second order [secondary] difference value at a calculation point indicated by (x,y). These three areas A, B, and C have an equal area which is determined by two parameters of "a" and "b" and the distance between the areas is represented by "d". These parameters "a", "b", "d" are determined experimentally. The calculation area determination unit 201 preliminarily determines the calculation areas for all calculation points and the result, together with information of duplicate calculation areas, is stored in the memory unit 203 (step S302).

Please rewrite the paragraph from page 12, line 13 through page 13, line 6, as follows:

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Then the calculation unit 202 calculates representatives of density values in the above calculation areas A, B, and C according to a method described hereinafter and further calculates the primary difference values and the second order [secondary] difference value. The primary difference values are two values, which are a value "e" resulting from subtraction of the density representative in the area B from the density representative in the area C and a value "f" resulting from subtraction of the density representative in the area A from the density representative in the area B. The second order [secondary] difference value is a value resulting from subtraction of the value "f" from the value "e". The primary difference values and second order [secondary] difference value calculated in this way are stored in the memory unit 203. From the duplicate information of the calculation areas stored in the memory unit 203, the primary difference values for duplicate calculation areas are obtained from the values stored in the memory unit 203 and the second order [secondary] difference value thereof is calculated using them (steps S303 and S304).

Please rewrite the paragraph from page 13, line 7 through page 13, line 26, as follows:

Then the judgment unit 204 judges the irradiation area ends from the primary difference values and the second order [secondary] difference values stored in the memory unit 203. Fig. 6B shows the second order [secondary] difference values calculated at the calculation unit 202. The second order [secondary] difference values are negatively large at the points X_1 and X_2 where the densities vary suddenly, and the aforementioned primary difference values f take positive values in a density increasing direction (when seen from the side of the point X_0) but take negative values in a density decreasing direction. From this property the judgment unit 204 judges that a point where the above second order [secondary] difference value is minimum and the primary difference values are positive is a candidate for an end point of the irradiation area. If there are plural candidates, the judgment unit determines that a first appearing candidate

is an end point of the irradiation area (step S305). Then the irradiation area end point is stored in the memory unit 203 (step S306).

Please rewrite the paragraph from page 13, line 27 through page 14, line 13, as follows:

Further, the judgment unit 204 judges whether the processing is completed for all the directions supplied from the calculation area input unit 200 and, if not, the processing is repeated from step S302 (step S307). After the irradiation area end points are determined in all the directions, the irradiation area determination unit 205 determines the irradiation area. Here, a line passing the end point of the irradiation area and being perpendicular to the calculation direction of the second order [secondary] difference value (for example, the direction from X_0 to X_3 in Figs. 5A and 5B) is calculated for all the end points of the irradiation area and an area surrounded by these lines obtained is determined as an irradiation area (step S308).

Please rewrite the paragraph from page 14, line 14 through page 14, line 20, as follows:

The present embodiment presents the effects of less computational complexity and capability of readily extracting the end point of the irradiation area, because the calculation unit 202 is arranged to calculate the representatives of density values in the calculation areas A, B, C and calculate the second order [secondary] difference value based on the representative values.

Please rewrite the paragraph from page 16, line 17 through page 16, line 20, as follows:

In the present embodiment, where the representative value of each area A, B, or C is $S(A)$, $S(B)$, or $S(C)$, respectively, the second order [secondary] difference value $SS(X)$ is calculated according to Eq. (1) below.

Please rewrite the paragraph from page 17, line 23 through page 18, line 3, as follows:

In other words, the above approach is nothing but an operation in which projection of pixel values is made with respect to a predetermined direction (the vertical direction) of the area, values obtained by the projection are smoothed using a one-dimensional morphology filter, and the second order [secondary] difference value is calculated with the distance d.

Please rewrite the paragraph from page 18, line 21 through page 19, line 6, as follows:

Since the device according to the present embodiment is arranged to determine the calculation areas comprised of the plural areas of the predetermined shape arranged in the predetermined direction, calculate the second order [secondary] difference value of the density values representing the respective areas in the plural areas, and judge one end point of the irradiation area from the second order [secondary] difference value thus calculated, the present embodiment presents the effects of capability of decreasing the computational complexity and in turn decreasing the computation time and capability of extracting the end points of the irradiation area with accuracy.

Please rewrite the paragraph from page 20, line 4 through page 20, line 23, as follows:

The judgment unit 2110 is composed of a second order [secondary] difference value calculation circuit 2201 for calculating the second order [secondary] difference value from data of an object area in an input image, a left end point extraction circuit 2202 for extracting a left end point of an irradiation area included in the object area, based on the second order [secondary] difference value calculated at the second order [secondary] difference value calculation circuit 2201, a right end point extraction circuit

2203 for extracting a right end point of the irradiation area included in the object area, based on the second order [secondary] difference value calculated at the second order [secondary] difference value calculation circuit 2201, and a diaphragm presence/absence judgment circuit 2204 for judging whether the object area is an area with an irradiation diaphragm or an area without an irradiation diaphragm, from the left end point extracted at the left end point extraction circuit 2202 and the right end point extracted at the right end point extraction circuit 2203.

Please rewrite the paragraph from page 21, line 25 through page 22, line 2, as follows:

First, when the area C is an object area, the second order [secondary] difference value calculation circuit 2201 calculates the second order [secondary] difference values $SS(x)$ data of the area C according to Eq. (21) below (step S2301).

Please rewrite the paragraph from page 22, line 9 through page 22, line 14, as follows:

Next, using the second order [secondary] difference values $SS(x)$ calculated at the second order [secondary] difference value calculation circuit 2201, the left end point extraction circuit 2202 extracts the left end point x_1 of the irradiation area included in the area C according to Eq. (22) below (step S2302).

Please rewrite the paragraph from page 22, line 19 through page 22, line 24, as follows:

On the other hand, using the second order [secondary] difference values $SS(x)$ calculated at the second order [secondary] difference value calculation circuit 2201, the right end point extraction circuit 2203 extracts the right end point x_2 of the irradiation area included in the area C according to Eq. (23) below (step S2303).

Please rewrite the paragraph from page 24, line 6 through page 24, line 13, as follows:

As described above, the present embodiment is arranged to calculate the second order [secondary] difference values $SS(x)$ from the data of the object area subjected to the judgment of presence/absence of the radiation diaphragm in the two-dimensional input image G and judge whether the object area is an area with or without the irradiation diaphragm, using the second order [secondary] difference values $SS(x)$.

Please rewrite the paragraph from page 24, line 27 through page 25, line 8, as follows:

It may also be contemplated that on the occasion of extracting the left end point x_1 and the right end point x_2 in the object area at the left end point extraction circuit 2202 and at the right end point extraction circuit 2203, another condition for the second order [secondary] difference values $SS(x)$ used in the extraction, for example such a condition that the second order [secondary] difference values $SS(x)$ are not more than a fixed threshold, is added.

Please rewrite the paragraph from page 26, line 19 through page 27, line 9, as follows:

The judgment unit 2140 is composed of, as illustrated in Fig. 10, a coordinate indication circuit 2404, a second order [secondary] difference value calculation circuit 2401 for calculating the second order [secondary] difference values from data of an object area (either one of the areas A to D in the input image G of Fig. 8 in this example) in the input image according to coordinates indicated by the coordinate indication circuit 2404, a left end point extraction circuit 2402 for extracting a left end point of the irradiation area included in the object area, based on the second order [secondary] difference values calculated at the second order [secondary] difference value calculation circuit 2401, and a right end point extraction circuit 2403 for extracting a right end point

of the irradiation area included in the object area, based on the second order [secondary] difference values calculated at the second order [secondary] difference value calculation circuit 2401.

Please rewrite the paragraph from page 28, line 6 through page 28, line 12, as follows:

The coordinate indication circuit 2404 is configured to give an indication of a coordinate for calculation of the second order [secondary] difference value at the second order [secondary] difference value calculation circuit 2401 thereto after the left end point extraction circuit 2402 and the right end point extraction circuit 2403 extract the left and right end points.

Please rewrite the paragraph from page 28, line 20 through page 28, line 25, as follows:

First, supposing the area C is an object area, the second order [secondary] difference value calculation circuit 2401 calculates the second order [secondary] difference values $SSi(x)$ from the data of the area C according to Eq. (25) below for each coordinate i indicated by the coordinate indication circuit 2404 (step S2501).

Please rewrite the paragraph from page 29, line 8 through page 29, line 12, as follows:

Using the second order [secondary] difference values $SSi(x)$ calculated at the second order [secondary] difference value calculation circuit 2401, the left end point extraction circuit 2402 then extracts the left end point xLi according to Eq. (26) below (step S2502).

Please rewrite the paragraph from page 29, line 21 through page 29, line 25, as follows:

Using the second order [secondary] difference values $SSi(x)$ calculated at the second order [secondary] difference value calculation circuit 2401, the right end point extraction circuit 2403 also extracts the right end point x_{Ri} according to Eq. (27) below (step S2504).

Please rewrite the paragraph from page 30, line 6 through page 30, line 11, as follows:

After completion of the storage of the left end point x_{Li} and the right end point x_{Ri} in the memory circuit 2405, the coordinate indication circuit 2404 gives another instruction of a coordinate i of a new horizontal line to the second order [secondary] difference value calculation circuit 2401 (step S2506).

Please rewrite the paragraph from page 30, line 12 through page 30, line 16, as follows:

According to this indication, the processing from step S2501 is carried out again. This loop processing is executed before the coordinate indication circuit 2404 gives an indication of the end to the second order [secondary] difference value calculation circuit 2401.

Please rewrite the paragraph from page 30, line 17 through page 30, line 25, as follows:

After steps S2501 to S2506 are carried out repeatedly and the processing is terminated according to the end indication from the coordinate indication circuit 2404, the memory circuit 2405 is in a storage state of the left end points x_{Li} and the right end points x_{Ri} corresponding to the coordinates i indicated during the processing by the coordinate indication circuit 2404 to the second order [secondary] difference value calculation circuit 2401.

Please rewrite the paragraph from page 33, line 3 through page 33, line 10, as follows:

As described above, the present embodiment is arranged to carry out the detection of the irradiation ends on the plural lines in the object area while the coordinate indication circuit 2404 gives the indications of the coordinates i of one-dimensional data lines crossing the object area in the horizontal direction to the second order [secondary] difference value calculation circuit 2401.

Please rewrite the paragraph from page 34, line 4 through page 34, line 11, as follows:

The present embodiment is arranged to calculate the second order [secondary] difference values $SS(x)$ according to above Eq. (21) and to extract the left end point x_l of the irradiation area included in the object area, using the second order [secondary] difference values $SS(x)$, for example, similar to Embodiment 2-1 described above. At this time the present embodiment also uses the sign of the primary difference value $S(x_l)$ given by Eq. (28) below.

Please rewrite the paragraph from page 35, line 16 through page 35, line 22, as follows:

The present embodiment is arranged first to calculate the second order [secondary] difference values from the data of the object area, for example similar to Embodiment 2-1, but at this time, the present embodiment is arranged to calculate the second order [secondary] difference values from data obtained after the data of the object area is filtered.

Please rewrite the paragraph from page 35, line 23 through page 36, line 1, as follows:

Specifically, for example, the image data of a one-dimensional line of an object area is represented by " $f(x)$ ", the data is subjected to a filtering process according to Eqs. (30) and (31) below, and the second order [secondary] difference values are calculated from the values $F2$ obtained as a result.

Please rewrite the paragraph from page 38, line 23 through page 39, line 2, as follows:

According to each coordinate i indicated by the coordinate indication circuit 3201, the characteristic value extraction circuit 3202 then calculates a characteristic value of one-dimensional image data corresponding to the coordinate i , for example, the second order [secondary] difference values $Ssi(y)$ according to Eq. (41) below (step S3302).

Please rewrite the paragraph from page 39, line 9 through page 39, line 15, as follows:

Using the second order [secondary] difference values $SSi(y)$ obtained at the characteristic value extraction circuit 3202, the end point extraction circuit 3203 then extracts a coordinate y_i of an end point (an irradiation end point) of the irradiation area included in the object area according to Eq. (42) below (step S3303).

Please rewrite the paragraph from page 41, line 10 through page 41, line 24, as follows:

Since the device is constructed to use the second order [secondary] difference value in order to extract the irradiation end, boundary points can be extracted with accuracy between an area irradiated directly and the other areas even in a photographic image obtained by photographing a subject with low transmittances of radiation. Therefore, the device of the present embodiment can judge the presence/absence of the irradiation diaphragm in the object area including the irradiation diaphragm in the object area including the irradiation area with accuracy. In addition, the presence/absence of the

irradiation diaphragm in the object area can be judged with accuracy even in a photographic image in which a portion with low radiation transmittances such as the abdominal part or the like overlaps with an end portion of the image.

Please rewrite the paragraph from page 41, line 25 through page 42, line 10, as follows:

Although the present embodiment is arranged to use the second order [secondary] difference value in order to make a judgment of the irradiation diaphragm, the apparatus of the present invention does not always have to be limited to this; for example, where change of density is quick at an irradiation end, the apparatus may also be arranged to use the primary difference values or higher-order difference values. In this case, the primary difference values or the higher-order difference values are obtained from the object area and a first appearing point of a value not less than a predetermined threshold is regarded as a candidate for an irradiation end.

Please rewrite the paragraph from page 43, line 16 through page 43, line 23, as follows:

The present embodiment is arranged to calculate the second order [secondary] difference values $SSi(y)$ according to above Eq. (41) and extract the irradiation end of the object area using the second order [secondary] difference values $SSi(y)$, for example, as Embodiment 3-1 described above was. At this time, the present embodiment also uses the sign of the primary difference value $Si(y)$ expressed by Eq. (44) below.

Please rewrite the paragraph from page 44, line 18 through page 44, line 24, as follows:

The present embodiment is arranged first to calculate the second order [secondary] difference values from the data of the object area, similar to Embodiment 3-1; but at this time, the data of the object area is subjected to a filtering process and the

second order [secondary] difference values are calculated from the data after the filtering process.

Please rewrite the paragraph from page 44, line 25 through page 45, line 3, as follows:

Specifically, for example, where the image data of a one-dimensional line of the object area is " $f(x)$ ", it is subjected to the filtering process according to Eq. (45) and Eq. (46) below and the second order [secondary] difference values are calculated from values $F2$ obtained as a result.

Please rewrite the paragraph from page 45, line 9 through page 45, line 16, as follows:

When Embodiment 3-1 is modified so as to calculate the second order [secondary] difference values after the data of the object area is smoothed by the filtering process as described above, whether the irradiation diaphragm is present or absent in the object area can be judged with better accuracy without being affected by the noise, particularly, without being affected by the noise on the line.

Please rewrite the paragraph from page 47, line 18 through page 47, line 24, as follows:

The characteristic quantity calculation means 4101 of Fig. 15 calculates the second order [secondary] difference values according to Eq. (51) below (steps S4101 and S4102). In the equation $f_i(x)$ represents image data of the i -th row line indicated by the coordinate indication means 4103, $S_{si}(x)$ the second order [secondary] difference values, and " c " a constant.

Please rewrite the paragraph from page 51, line 16 through page 51, line 22, as follows:

In the present embodiment, where the image data of a one-dimensional line is $f(x)$ and the second order [secondary] difference values thereof are $SS(x)$ defined by Eq. (1), the sign of the primary difference value $S(XL)$ of Eq. (60) below is also added to the operation of extracting the end point XL at the end point extraction means 4102 (Fig. 15).

Please rewrite the paragraph from page 52, line 10 through page 52, line 17, as follows:

In the present embodiment, where the one-dimensional data of the i -th row is $f_i(x)$ and is subjected to the filtering process according to Eqs (64) and (65) below and values resulting from the filtering process are defined as $F_{li}(x)$ and $F_{2i}(x)$, characteristic quantity calculation means 4101 (Fig 15) uses $F_{2i}(x)$ for calculating the second order [secondary] difference values defined by Eq. (51).

Please rewrite the paragraph from page 52, line 26 through page 52, line 27, as follows:

Hence, the second order [secondary] difference values are calculated as follows.

Please rewrite the paragraph from page 53, line 3 through page 53, line 8, as follows:

As described above, the present embodiment is arranged to smooth the one-dimensional image data for calculation of the second order [secondary] difference values by the filtering process, thereby accomplishing the effect of being not affected by the noise, particularly by the noise on the line.

Please rewrite the paragraph from page 55, line 18 through page 56, line 9, as follows:

Fig. 19 is a block diagram to show the structure of an area extraction device according to the present embodiment. In Fig. 19, reference numeral 4301 designates a second order [secondary] difference value calculation means for calculating the second order [secondary] difference values of one-dimensional image data in a designated direction (for example, which is determined according to the value determined by the angle extraction device described above), 4302 a left end point extraction means for extracting a left end point of the area, based on the second order [secondary] difference values calculated at the second order [secondary] difference value calculation means 4301, and 4303 a right end point extraction means for extracting a right end point of the area, based on the second order [secondary] difference values calculated at the second order [secondary] difference value calculation means 4301. Fig. 20 is a flow chart of a processing procedure sequence in the area extraction device according to the present embodiment.

Please rewrite the paragraph from page 56, line 10 through page 56, line 19, as follows:

The flow of the processing in the present embodiment will be described according to Fig. 20. The second order [secondary] difference value calculation means 4301 (Fig. 19) calculates the second order [secondary] difference values $SS(x)$ according to a calculation equation defined by Eq. (71) below (step S4301). Here, $f(x)$ represents the one-dimensional data of a line crossing the area in the designated direction and x represents coordinates thereof. Further, "d" denotes a constant indicating a difference distance.

Please rewrite the paragraph from page 57, line 7 through page 57, line 10, as follows:

As described above, since the present embodiment uses the second order [secondary] difference values, it has the effect of capability of extracting the area with accuracy even if the density change is gentle at the area end.

Please rewrite the paragraph from page 58, line 3 through page 58, line 24, as follows:

Fig. 21 is a block diagram to show the structure of an area extraction device according to the present embodiment. In Fig. 21, reference numeral 4401 designates a second order [secondary] difference value calculation means for calculating the second order [secondary] difference values of one-dimensional image data in a designated direction (for example, which is determined according to the value determined by the angle extraction device described above) indicated by a coordinate indication means 4404, 4402 a left end point extraction means for extracting a left end point of the area, based on the second order [secondary] difference values calculated at the second order [secondary] difference value calculation means 4401, a right end point extraction means for extracting a right end point of the area, based on the second order [secondary] difference values calculated at the second order [secondary] difference value calculation means 4401, and 4404 the coordinate indication means for indicating a coordinate of one-dimensional data for calculation of the second order [secondary] difference values at the second order [secondary] difference value calculation means 4401 after extraction of the right area end at the right end point extraction means 4403.

Please rewrite the paragraph from page 59, line 10 through page 59, line 19, as follows:

The second order [secondary] difference value calculation means 4401 (Fig. 21) calculates the second order [secondary] difference values $SSi(x)$ according to a calculation equation defined by Eq. (75) below (step S4401). Here, $fi(x)$ represents one-dimensional data of a line crossing the area in the designated direction, x coordinates thereof, and "i" a coordinate of the row in the designated direction indicated by the

coordinate indication means 4404. Here, "d" represents a constant indicating a difference distance.

Please rewrite the paragraph from page 61, line 1 through page 61, line 5, as follows:

As described above, since the present embodiment uses the second order [secondary] difference values, the boundary points of the area can be extracted with accuracy even if the density values vary gently at the boundary of the area.

Please rewrite the paragraph from page 61, line 12 through page 61, line 19, as follows:

In the present embodiment, where the image data of a one-dimensional line in the designated direction is expressed by $f(x)$ and the second order [secondary] difference values thereof by $SS(x)$ defined by Eq. (78) below, the sign of the primary difference value $S(XL)$ defined by Eq. (79) below is added to the extraction of the left end point XL at the left end point extraction means 4302 (Fig. 19) or 4402 (Fig. 21).

Please rewrite the paragraph from page 62, line 17 through page 62, line 24, as follows:

In the present embodiment, where the one-dimensional data in the designated direction is defined by $f(x)$ and values resulting from the filtering process according to Eqs. (83), (84) below are defined by $F1(x)$, $F2(x)$, the values $F2(x)$ are used for calculation of the second order [secondary] difference values at the second order [secondary] difference value calculation means 4301 (Fig. 19) or 4401 (Fig. 21).

Please rewrite the paragraph from page 63, line 6 through page 63, line 11, as follows:

As described above, since the present embodiment is arranged to smooth the one-dimensional image data for the computation of the second order [secondary] difference values by the filtering process, it has the effect of being not affected by the noise, particularly, by the noise on the line.

IN THE CLAIMS

Please note the following changes to claims 1-9, 23, 24, 26, 27, 29, 30, and 31:

1. (Twice Amended) An image processing method comprising:
a step of determining a plurality of areas, each of which includes a plurality of pixels, arranged in a [predetermined] direction on an image [and each having a predetermined shape];
a step of calculating a [secondary] second order difference values from [a plurality of primary difference values, wherein each primary difference value corresponds to a difference between density] values each of which represents a [respective area in said] different one of the plurality of areas; and
a step of [judging] obtaining an end point of an irradiation area from [said secondary] the second order difference values calculated in said [calculating] calculation step.
2. (Amended) A method according to Claim 1, further comprising a step of [determining said] extracting the irradiation area from a plurality of end points [of the irradiation area judged] obtained in said [judging] obtaining step.
3. (Amended) A method according to Claim 1, wherein [said density] each of the values representing [the respective areas in said] different one of the plurality of areas [are] is an average [density] value[s] of pixel values in the [respective] corresponding area[s].

4. (Amended) A method according to Claim 1, wherein [said density] each of the values representing [the respective areas in said] different one of the plurality of areas [are] is a median[s] [of density] value[s] of pixel values in the [respective] corresponding area[s].

5. (Amended) A method according to Claim 1, wherein [said density] each of the values representing [the respective areas in] different one of the plurality of areas [are] is an average[s of density] value[s at a limited number of points] of a limited number of pixel values in the [respective] corresponding area[s].

6. (Amended) A method according to Claim 1, wherein [said density] each of the values representing [the respective areas in] different one of the plurality of areas [are] is a median[s of density] value[s at] of a limited number of [points] pixel values in the [respective] corresponding area[s].

7. (Amended) A method according to Claim 1, wherein [said density] each of the values representing [the respective areas in] different one of the plurality of areas [are] is calculated [using integrated] by integrating pixel values in a [predetermined] direction [of pixels] in [said plurality of] the corresponding area[s].

8. (Amended) A method according to Claim [7] 1, wherein [said density] each of the values representing [the respective areas in said] different one of the plurality of areas [are] is obtained by smoothing [said integrated] pixel values in the corresponding area.

9. (Twice Amended) An image processing method comprising:
a step of detecting an [irradiation] end[,] point of an irradiation area based on [a density distribution in each area, for a plurality of areas in a desired direction in said] pixel values in an object area of an image; and
a step of evaluating a detection result [of said detection, based on said detected irradiation ends for said plurality of areas] in said detection step; and

[wherein said detection step comprises calculating a second order [secondary] difference value from a plurality of primary difference values, wherein each primary difference value corresponds to a difference between density values each of which represents a respective area in each of said plurality of areas.]

a step of judging whether an irradiation area is limited in the object area based on an evaluation result in said evaluation step.

23. (Twice Amended) An image processing apparatus, comprising:
means for determining a plurality of areas, each of which includes a plurality of pixels, arranged in a [predetermined] direction on an image [and each having a predetermined shape];

means for calculating [a secondary] second order difference values from [a plurality of primary difference values, wherein each primary difference value corresponds to a difference between density] values each of which represents a [respective area in] different one of the [said] plurality of areas; and

means for [judging] obtaining an end point of an irradiation area from [said secondary] the second order difference values calculated by said calculating means.

24. (Twice Amended) An image processing apparatus comprising:
means for detecting an [irradiation] end[,], point of an irradiation area based on [a density distribution in each area, for a plurality of areas in a desired direction in said] pixel values in an object area of an image; [and]

means for evaluating a detection result [of said detection, based on said detected irradiation ends for said plurality of areas] by said detection means; and

[wherein said means for detecting comprises means for calculating a second order [secondary] difference value from a plurality of primary difference values, wherein each primary difference value corresponds to a difference between density values, each of which represents a respective area in each of said plurality of areas.]

means for judging whether an irradiation area is limited in the object area based on an evaluation result by said evaluation means.

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26. (Twice Amended) A computer-readable storage medium storing a program for [carrying out] making a computer execute an image processing [routine] method, said method comprising:

a step of determining a plurality of areas, each of which includes a plurality of pixels, arranged in a [predetermined] direction on an image [and each having a predetermined shape];

a step of calculating [a secondary] second order difference values from [a plurality of primary difference values, wherein each primary difference value corresponds to a difference between density] values each of which represents a [respective area in said] different one of the plurality of areas; and

a step of [judging] obtaining an end point of an irradiation area from [said secondary] the second order difference values calculated in said calculating step.

27. (Twice Amended) A computer-readable storage medium storing a program for [carrying out] making a computer execute an image processing [routine] method, said method comprising:

a step of detecting an [irradiation] end[,] point of an irradiation area based on [a density distribution in each area, for a plurality of areas in a desired direction in said] pixel values in an object area of an image; [and]

a step of evaluating a detection result [of said detection, based on said detected irradiation ends for said plurality of areas] in said detection step; and

[wherein said detecting step comprises calculating a second order [secondary] difference value from a plurality of primary difference values, wherein each primary difference value corresponds to a difference between density values each of which represents a respective area in each of said plurality of areas.]

a step of judging whether an irradiation area is limited in the object area based on an evaluation result in said evaluation step.

29. (Amended) An apparatus for a radiographic image, comprising:

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a [determination] unit adapted to determine a plurality of [discrete positions] pixels arranged at intervals of at least two pixel pitches in a direction on a radiographic image;

a [calculation] unit adapted to calculate [a] characteristics [on the basis] of pixel values of [said] the radiographic image at [each] every successive [three] plural pixels of [said] the plurality of [discrete positions] pixels; and

a [judgment] unit adapted to [determine] obtain an end point of an irradiation area in [said] the radiographic image [on the basis of] based on [said] the characteristics calculated by said calculation unit.

30. (Amended) A method of processing a radiographic image, comprising:

a [determination] step of determining a plurality of [discrete positions] pixels arranged at intervals of at least two pixel pitches in a direction on a radiographic image;

a [calculation] step of calculating [a] characteristics [on the basis] of pixel values of [said] the radiographic image at [each] every successive [three] plural pixels of [said] the plurality of [discrete positions] pixels; and

a [judgment] step of [determining] obtaining an end point of an irradiation area in [said] the radiographic image [on the basis of] based on [said] the characteristics calculated in said calculation step.

31. (Amended) A computer-readable storage medium storing a program for [carrying out] making a computer execute a method of processing a radiographic image, said method comprising:

a [determination] step of determining a plurality of [discrete positions] pixels arranged at intervals of at least two pixel pitches in a direction on a radiographic image;

a [calculation] step of calculating [a] characteristics [on the basis] of pixel values of [said] the radiographic image at [each] every successive [three] plural pixels of [said] the plurality of [discrete positions] pixels; and

a [judgment] step of [determining] obtaining an end point of an irradiation area in [said] the radiographic image [on the basis of] based on [said] the characteristics calculated in said calculation step.

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